NEAR INFRARED REFLECTANCE SPECTROSCOPY TO PREDICT MUSCLE ORIGIN IN BEEF PRODUCTION SYSTEMS IN URUGUAY

D. Cozzolino [1], D. De Mattos [2] and D. Vaz Martins [3] . Instituto Nacional de Investigacion Agropecuaria. INIA. Ruta 50 - km 11. Colonia – Uruguay. Fax: ++ 598 574 8012. South America.[1] Animal Nutrition - INIA La Estanzuela. Email: cozolino@inia.org.uy [2] Beef Project - INIA Tacuarembo. Email. ddmatto@inia.org.uy. [3] Beef Project - INIA La Estanzuela. Email: *vazmarti@inia.org.uy*

Background

The quality of meat is highly variable in many properties. Muscles "as meat" can be diced, chopped or minced and are usually handled in bulk. The composition of such material can be extremely variable and easily manipulated (Patterson and Jones, 1990). This has imposed great pressure on the food manufacturing industry to guarantee the safety of meat, as well as its process. Recently, there is a demand for rapid and low cost methods of direct quality measurements in both food and food ingredients to establish their authenticity and hence guarantee the quality of products manufactured for consumers. NIRS technology is not only used to assess chemical structures through the analysis of the molecular bonds in the near infrared spectrum, but also to build an optical model characteristic of the sample which behaves like the "finger print" of the sample. This opens the possibility of using spectra to determine complex attributes of organic structures, which are related to molecular chromophores, organoleptic scores and sensory characteristics (Hildrum et al., 1994, 1995; Park et al., 1998).

Objective

The objectives of this present work were: (1) to examine two methods of sample presentation to the instrument (intact and minced) and (2) to explore the use of principal component analysis (PCA) and Soft Independent Modelling of Class Analogy (SIMCA) to classify muscles by quality attributes.

Materials and Methods

Seventy-eight (n: 78) muscles *Longissimus dorsi* from Hereford steers (live weights ranged from 350 – 450 kg) were taken after slaughter, packed in polyethylene bags and stored in a conventional freezer (temperature – 20 ^{0}C) for 40 to 60 days before scan. Thirty (n: 39) samples came from steers fed only on a diet based on 100 per cent pastures (composite with a mixtures of grasses and legumes) (P), while the others (n: 39) were fed with a diet based mainly on corn silage (CS) (about 80 per cent of the diet). About 100 to 200 g of frozen muscle was thawed at room temperature (20 – 22 ^{0}C) and homogenised. Intact samples were prepared by cutting slices parallel to the longitudinal orientation of the muscle fibres (100 mm x 50 mm x approximately 20 mm thick) from the thawed muscle sample. Chemical analyses were performed on the fresh samples after thawed (AOAC, 1990). Samples were scanned both intact and minced in reflectance mode (400 – 2500 nm) in a scanning monochromator NIRS 6500 (NIRSystems, Silver Spring, MD, USA) using NIRS 2 software, version 3.01, from Infrasoft International (ISI, Port Matilda, PA, USA). Intact samples were scanned in a rectangular cup (100 mm x 50 mm) approximately 15-mm thickness. Minced samples were scanned in a circular cup (50 mm diameter, 10 mm depth). Reflectance data were stored as log (1/R) (where R: reflectance) at two nm intervals. Principal Component Analysis (PCA), is a statistical procedure for resolving data sets into orthogonal components whose linear combinations approximate the original data to any desired degree of accuracy (Martens and Naes, 1996). PCA was used to derive the first 20 principal components from the condensed spectral data. These were used in further analysis to examine the natural groupings of the samples. The CENTER program ranks spectra in a file according to their Mahalanobis distance (H statistic) from the average spectra of the file using PC scores (NIRS 2, 1995). In order to visualise the relative position of samples from both P and CS feeding system, samples were graphically displayed by means of the first pair components one and two or second pair two and three, with the SYMMETRY program of the same software (ISI, 3.01). The classification method applied was SIMCA (Soft Independent Modelling of Class Analogy). SIMCA is based on making a PCA model for each class in the training set (The Unscrambler, V. 6.11; CAMO, 1986 - 1996).

Results and Discussion

Figure 1 shows the mean spectrum of both intact and minced samples. Compared with minced samples, intact samples reflected less energy, resulting in greater log (1/R) values throughout the spectrum between 400 and 1900 nm. The difference between intact and minced samples in energy reflectance may be due to a light scattering effect resulting from variations in particles size associated to muscle structure (myofibrillar birefringence, macroscopic surface reflectance, sarcomere length). The score - plots showed two clusters of data related with the feeding systems. Muscles from the same feeding system are plotted near each other or rather apart from each other. Moisture, pigments and fat could explain the discrimination between the two groups of feeding systems. The PCs weight showed a shape similar to the intact and minced mean spectrum (not presented) (Cowe and McNicol, 1985). PC1 explained 70.9 per cent of the total variance in the intact set of samples. The highest loading on PC1 were found around 1440 and 1918 nm respectively. This spectral region is characteristic for water absorption (OH overtones) (Murray, 1986) and related with moisture content of the beef muscles. PC2 explained 12.2 per cent, the weight plot of the PC2 strongly showed an invert of the intact spectrum. In this work, the highest loading on PC2 were found around 570 nm, 1412 nm, 1632 and 1860 nm respectively. These spectral regions are characteristics for the respiratory meat pigments at 570 nm and for water at 1412 nm respectively. Some authors reported that absorbance shoulders between 450 and 510 nm correspond to light absorption by carotenoid pigments presents in fat tissue (Prache and Theriez, 1999). Animal fed with pastures had more carotenoid content than fed with concentrates (corn silage or grain). Thus, different carotenoid content of both lean and adipose tissue could explain the differences between muscle samples. Absorption between 1600 – 1850 nm was related to the type of fat present in the sample (Murray, 1986). Spectral bands in the region at 1638 nm and between 2200 nm to 2300 nm were related to unsaturated = C – H and C = C groups (Murray, 1986) which suggests that differences in polyunsaturated fatty acids may also contribute for further muscle classification. High levels of linoleic acid (C18: 2), diterpenoids (C: 20 hydrocarbons), PUFA and less C: 16 and C: 17 in animals fed on pastures compared with those fed with grain and pastures were reported in the literature (Griebenow et al., 1997). These spectral regions could explain the discrimination among muscle samples derived from the different feeding system. Optical properties of the samples gave an excellent differentiation of beef muscles either from pastures or corn silage feeding system. NIRS classify correctly up 80 to 83 per cent of samples from pastures basis. In both sets of samples (intact and minced), the poorest classification was relates with corn silage feeding system (79 – 80 per cent).

Conclusions

NIRS showed its potential as analytical tool for a rapid screening of meat samples originated from different feeding systems. At more specific level, this approach provides a new source of classification of muscles using their optical properties. The spectra would appear to be

the most appropriate and convenient methods of tissue food classification for industrial purposes and to address consumer concern for authentication and traceability.

References

AOAC. 1990. Official methods of analysis of the Association of Official Analytical Chemists. *Edited by K. Helrich. Published by the Association of Official Analytical Chemists, Inc., 15th edition, Arlington, Virginia; USA. 1298 pp.*

Griebenow, R.L.; Martz, F.A. and Morrow, R.E. 1997. Forage based beef finishing systems: a review. *Journal of Production in Agriculture* **9**: 84 – 91.

Hildrum, K.I.; Nilsen, B.N.; Mielnik, M. and Naes,T. 1994. Prediction of sensory characteristics of beef by near infrared spectroscopy. *Meat Science* **38**: 67 - 80.

Martens, H. and Naes, T. 1996. Multivariate Calibration. *John Wiley and Sons Ltd., Co. New York. 419 pp*

Murray, I. 1986. The NIR spectra of homologous series of organic compounds. *In. NIR/NIT Conference. Edited by J.Hollo, K.J. Kaffka and Gonczy J.L. Akademiai Kiado, Budapest.* pp 13 - 28.

Park, B.; Chen, Y.R.; Hruschka, W.R.; Shackelford, S.D. and Koohmaraie, M. 1998. Near infrared reflectance analysis for predicting beef Longissimus tenderness. *Journal of Animal Science* **76**: 2115 – 2120.

Patterson, R.L.S. and Jones, S.J. 1990. Review of current techniques for the verification of the species origin of meat. *Analyst* **115 :** 501 - 505.

Prache, S. and Theriez, M. 1999. Traceability of lamb production systems: carotenoids in plasma and adipose tissue. *Animal Science* **69**: 29 – 36.

Figure 1. Visible and NIRS mean spectrum of intact samples (whole line) and minced samples (dotted line) in nm (wavelengths in nm).

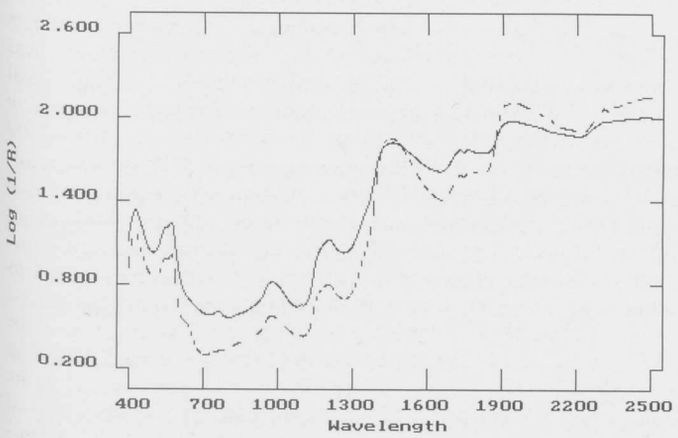

Figure 2. Score plots for beef muscle samples ■ (corn silage) and ●(pastures).